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Agricultural Research Administration  
Bureau of Entomology and Plant QuarantineUSE OF INSECT REPELLENTS AND TOXICANTS<sup>1/</sup>By B. V. Travis, F. A. Morton, and Carroll N. Smith  
Division of Insects Affecting Man and Animals

During the last several years thousands of chemicals have been tested to determine their value in repelling various kinds of insects. Out of this large number a few new repellents and toxicants have been developed that give effective protection from the bites of mosquitoes, punkies (no-see-ums), black flies and other biting flies, and chiggers. Unlike the older repellents, these materials have little or no odor and they remain effective from two to several hours even when the insects occur in large numbers. This publication gives information on their availability, use, and effectiveness. Although they were developed primarily for military use, they can also be used safely by civilians.

## Formulations

The following materials are effective and safe for general use, individually or in combinations: Dimethyl phthalate, dimethyl carbate, Indalone, and 2-ethyl-1,3-hexanediol (Rutgers 612).

These chemicals vary greatly in their effectiveness against different insects and on different individuals. Certain materials that are satisfactory against some species may fail to repel others. Laboratory and field tests have shown that the following mixtures are effective against a wide range of insect species and on more individuals than any one of the chemicals when used alone (figures in parts by weight):

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<sup>1/</sup> The data in this paper were obtained in connection with investigations conducted with funds allotted to this Bureau by the Department of the Army.

Formula 1 (M-2020)

Dimethyl phthalate - - - - 4  
Dimethyl carbate - - - - 3  
2-Ethyl-1,3-hexanediol- - 3

Formula 2 (M-250)

Dimethyl phthalate - - - - 3  
Indalone- - - - - - - - 1  
2-Ethyl-1,3-hexanediol- - 1

Formula 3 (M-1616)

Dimethyl phthalate - - - - 3  
Indalone- - - - - - - - 1  
Dimethyl carbate - - - - 1

Mixtures containing two repellents are also fairly effective, but they do not repel so wide a range of insects for so long periods as do the triple mixtures. Examples of such mixtures are:

Formula 4

Dimethyl phthalate - - - - 2  
2-Ethyl-1,3-hexanediol- - - 1

Formula 5

Dimethyl phthalate - - - - 2  
Dimethyl carbate - - - - 1

Effect on Skin

These chemicals and some of their mixtures have been tested by toxicologists and have been found safe for use as skin applications. They are toxic if taken internally. Occasionally there are people who are allergic to certain of the materials that have passed toxicological tests. A few persons may show slight rash or other minor skin reaction to some of the repellents. Any of the effective and toxicologically safe repellents may cause some smarting when applied to the mucous membranes and to areas where the skin is especially tender, such as the eyelids or groin region or where there are skin abrasions. CARE SHOULD BE TAKEN NOT TO APPLY ANY OF THE APPROVED MATERIALS TOO LIBERALLY ON THE FOREHEAD OR EYELIDS, AS THEY CAUSE A RATHER SEVERE BUT TEMPORARY STINGING IF THEY GET INTO THE EYES. The treated skin will at first feel warm, especially if it is moist with sweat, but ordinarily the sensation lasts only a few minutes and causes no injury.

Effect on Paints, Plastics, and Other Synthetic Materials

All these repellents are solvents for paints, varnishes, and many of the plastics. They must be used with caution, as they will damage such materials as plastic watch crystals, some types of synthetic cloth

(sharkskin, rayon, but not nylon), fingernail polish, and articles that are painted or varnished or made of plastics. They will not damage cotton or wool cloth if it contains no synthetic fibers.

2-Ethyl-1,3-hexanediol is much less injurious to painted surfaces than the other materials, and relatively noninjurious to plastics. For this reason many persons prefer to use this material alone rather than one of the mixtures.

### Use Against Mosquitoes, Flies, and Biting Gnats

A repellent must be uniformly distributed over the area to be protected. Otherwise the insects will seek out and bite in any small area where the repellent was not thoroughly applied.

Application to skin.--All these repellents feel oily on the skin and for this reason may be objectionable to use. However, materials of this type give more complete and longer protection than do the less viscous materials, which either evaporate or are absorbed shortly after application. Because the conditions of use are variable, the only rule to follow is to apply them when the insects resume biting on the treated areas. Under favorable conditions one treatment may last several hours on some people.

The most common method of using repellents is to shake a few drops from the bottle into the palms, smear evenly, and then apply thoroughly to the backs of the hands, wrists, neck, ears, face, or any other exposed skin, much as in washing. This procedure should be repeated until a uniform oily film is obtained.

Application to clothing.--Repellents sprayed or daubed on clothing where the bites occur will be effective for several days if the clothing remains dry. One soaking with water, however, removes enough of the repellent to make treating clothing noneffective. (See Effect on Paints, Plastics, and Other Synthetic Materials.)

A simple method of applying a repellent to clothing is to shake about a dozen drops into one hand, rub the hands together, and rub lightly on socks, shirts, or trousers where bites occur. Repeat this procedure until the areas to be treated have been covered. If you prefer, use a small hand sprayer to spray lightly the areas where the insects are biting.

Shirts, stockings, or other garments may be treated by saturating them with a solution or emulsion of a repellent, as described for use against chiggers. The repellent that provides the most durable treatment of clothing is Indalone. Garments treated with this repellent will remain effective through 2 to 3 days of ordinary wear, but not after washing or prolonged soaking in water.

## Use Against Chiggers

Any of the repellents mentioned will give protection from chigger bites if properly applied. The action on chiggers, or red bugs, is largely as a toxicant, which kills them, rather than as a repellent. The material should be applied to the clothing rather than to the skin. Re-treatment is necessary after washing or soaking in water. Benzyl benzoate is also very toxic to chiggers. Clothing treated with it will remain effective after two ordinary home launderings.

There are several methods of applying these chemicals for protection against chiggers.

Hand application.--The simplest way for the individual to treat his own clothing is to pour about a dozen drops into one hand, rub the hands together, and then rub lightly on the socks and other clothing. The most liberal applications should be made along all openings of the clothing, such as inside the neck band, and the fly and cuffs of trousers.

Spray method.--The material may be applied to the clothing with a sprayer as for protection from mosquito bites, with special attention to the openings to the clothes. See Barrier method.

Barrier method.--Considerable protection will be obtained by applying the material only to the openings of the clothes--inside the neck band, fly, and cuffs of shirt; inside the waist band, fly, and cuffs of trousers; and on the socks, both above the shoes and inside, below the tongue. The material may be applied by daubing, spraying, or drawing the mouth of the bottle along the cloth to apply a thin layer 1/2 inch wide. Women's clothing may be protected in the same general way.

If one is not going to be crawling about on the ground, nearly complete protection can be obtained by smearing the toxicant only on the socks above the shoe tops and on the bottoms of the trouser legs.

Immersion method.--Field clothing can be immersed in a solution or emulsion of the toxicant. Benzyl benzoate is preferable for this purpose, as it is more resistant to leaching by water. About 1/15 ounce of toxicant per square foot of cloth should be used, or 2 ounces to a jacket, trousers, and socks of medium size. The underwear need not be treated.

The toxicant may be dissolved in enough dry cleaning fluid to wet the garment thoroughly without leaving any excess, about 1 1/2 quarts for an outfit of heavy cotton cloth. After all parts of the garment have been saturated with the solution, the cleaning fluid should be allowed to evaporate, leaving the cloth impregnated with the toxicant.

For use as an emulsion the most practical method is to prepare a concentrate by dissolving one of the following emulsifiers in the acaricide, using 10 parts by weight of the emulsifier to 90 parts of the toxicant:

Stearate 61-C-2280 (a polyalkylene glycol stearate)  
Tween 60 (sorbitan monostearate, polyoxyalkylene derivative)  
Tween 80 (sorbitan monooleate, polyoxyalkylene derivative)  
Polymerized glycol monostearate, monooleate, or monolaurate  
Span 60 (sorbitan monostearate) and Tween 60, equal parts  
Span 80 (sorbitan monooleate) and Tween 80, equal parts

To make the emulsion in which to dip the clothing, add 1/2 pint of this concentrate to 1 gallon of water. Agitate vigorously 1 part of the concentrate in 2 or 3 parts of water to form a creamy emulsion and then dilute with the remainder of water, using moderate agitation. One gallon of emulsion is sufficient to dip a set of field trousers, shirts, and socks. After dipping, wring out the garments lightly and dry before wearing.

#### Use Against Ticks

None of the repellents or toxicants deemed safe for use will provide complete protection from ticks, but several of them will afford a high degree of protection against the most abundant species, the lone star tick. Treat the socks and all the outer clothing by the immersion method described for use against chiggers. The best repellents for use against ticks, in order of preference, are Indalone, dimethyl carbate, dimethyl phthalate, and benzyl benzoate. Other, more effective, compounds are still being studied for their toxicity to mammals, and may eventually be released for general use. Treated clothing remains effective through several days of ordinary wear, but not through washing.

#### Sources of Materials

These materials may be obtained from the following firms. This list does not include all firms, and no discrimination is intended or implied for names omitted, nor is warranty given as to the grade or standard of the product.

#### Commercial Mixtures

Carbide and Carbon Chemicals Corp., Fine Chemicals Division,  
30 E. 42nd St., New York, N. Y.  
The J. B. Williams Co., 420 Lexington Ave., New York, N. Y.  
U.S. Industrial Chemicals, Inc., 60 E. 42nd., New York, N. Y.



## Repellents or Toxicants

### Benzyl benzoate

Practically any large chemical firm or your local druggist.

### Dimethyl carbate

Sowa Chemical Co., 305 E. 46th St., New York, N. Y.

U.S. Industrial Chemicals, Inc., 60 E. 42nd St., New York, N. Y.

### Dimethyl phthalate

Practically any large chemical firm or your local druggist.

### 2-Ethyl-1,3-hexanediol

Carbide and Carbon Chemicals Corp., Fine Chemicals

Division, 30 E. 42nd St., New York, N. Y.

### Indalone

Kilgore Chemicals, Inc., 812 N. Fairfax, Alexandria, Va.

U.S. Industrial Chemicals, Inc., 60 E. 42nd St., New York, N. Y.

## Emulsifiers

Polymerized glycol monolaurate, monostearate, and monooleate

Glyco Products Co., Inc., 26 Court St., Brooklyn, N. Y.

### Spans and Tweens

Atlas Powder Co., 9th and Market Sts., Wilmington, Del.

### Stearate 61-C-2280

Carbide and Carbon Chemical Corp., Fine Chemicals

Division, 30 E. 42nd St., New York, N. Y.

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